Short-Term Hearing Aid Benefit in a Large Group

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Abstract

Short-term benefit in a very large group (N = 4,584) following hearing aid treatment was estimated using a revised version of the Self-Assessment of Communication (SAC-Hx). A total of 4,584 veterans with adult-onset hearing loss and mean audiometric findings consistent with a mild to severe, sloping, symmetrical, sensorineural hearing impairment were fitted with hearing aids. Responses to the SAC-Hx were gathered prior to and then 6 weeks following hearing aid fitting. Benefit was defined as the difference between the baseline and the posttreatment SAC-Hx scores. Hearing aid treatment resulted in robust and statistically significant benefit in each category of self-perceived communication consequences. Prior experience influenced benefit: New hearing aid users demonstrated the greatest magnitude of benefit, but even previously satisfied and dissatisfied users obtained significant benefit after new hearing aid fitting. Duration of experience did not have a remarkable effect on the magnitude of benefit: All groups with various durations of experience obtained comparable benefit. Severity of the baseline scores paralleled degree of hearing impairment when impairment was defined using a better ear pure tone average at 1,000, 2,000, 3,000, and 4,000 Hz. Also, severity of perceived communication consequences paralleled poorer monosyllabic word recognition. Hearing aid treatment provided a functional, robust, and statistically significant benefit to individuals in all categories of hearing impairment (normal, mild, moderate, severe, and profound). This report demonstrates the feasibility of the SAC-Hx as a tool to efficiently assess outcome domains in hearing aid fitting.

Keywords

hearing aids, self-assessment, rehabilitation of hearing impaired, treatment outcome

Introduction

The consequences of impairment on the functioning of an individual are numerous, complex, and have been characterized as "biopsychosocial" (World Health Organization, 2002). For the majority of persons who seek treatment for hearing problems consequent to hearing impairment, acquisition of hearing aid amplification is typically the initial and the most commonly attempted remedy. Not surprisingly, approximately 75% of audiologists in practice in the United States are engaged in the direct dispensing of hearing aids (Schow & Nerbonne, 2007). According to Beck (2000), demonstration of health care value has emerged alongside health care cost containment as a focal area of emphasis in the transformation of health care delivery in the United States. Mirroring this trend, the American Academy of Audiology Guidelines for the Audiological Management of Adult Hearing Impairment call for the utilization of treatment outcome measures to demonstrate that hearing aid amplification reduces the consequences of hearing impairment, improves quality of life, and accordingly, provides health care value (Valente et al., 2006).

Hearing aid amplification as treatment may be operationally defined as a process that includes the amplification device itself, plus counseling and other audiological rehabilitative procedures. Following hearing aid fitting and verification procedures, outcomes can be assessed objectively or subjectively. According to Humes (1999), an objective measurement can be scored as either "correct" or "incorrect" based on a comparison with a known external reference (e.g.,

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in the repetition of a specific word), whereas a subjective measurement requires the expression of an opinion or judgment for which there is no true external reference. Treatment outcomes may be assessed objectively for aided performance, such as in speech recognition procedures, or subjectively, as in the self-report domains of satisfaction, quality of life, benefit, use, impact on others, residual participation restrictions, and residual activity limitations (Cox, Alexander, & Beyer, 2003). In general, benefit is the difference between unaided versus aided listening and can be assessed with either objective or subjective measurement tools. For an individual hearing aid user, subjective benefit exists when the following question can be answered in the affirmative: "Does the hearing aid help you?" Specifically, the subjective perception of hearing aid benefit likely includes reduction in activity limitations for communication, reduction in restrictions in participation in life, community and social activities, reduction in negative emotions, and an improvement in quality of life—experiences neither easily nor comprehensively captured in the environment of the audiology clinic or hearing aid dispensing office. Any of these expressions of hearing aid benefit serve to inform interested parties (potential users, significant others, and third-party payers) whether the treatment justifies the expenditure of time, effort, and health care dollars.

Hearing aids cost more now than they ever have in the past, and presumably, these increased costs are linked to professional labor costs associated with the fitting and rehabilitation process as well as technological advances in the devices themselves, such as digital signal processing, directional microphones, and further miniaturization. A review of retail pricing reveals that a typical hearing aid cost approximately $370 in 1984, rising to $728 in 1994, and to $1,986 in 2007 (Cranmer-Briskey, 1994; Johnson, 2008; Mahon, 1984). These prices reflect an approximate quintupling of the cost from 1984 to 2006 compared with a doubling of the Consumer Price Index over the same period (Bureau of Labor Statistics, 2008). The rising costs associated with the provision of hearing aid amplification will likely fuel a demand by consumers and third-party payers for justification of outcomes because, as Dillon, Birtles, and Lovegrove (1999) stated, "It is reasonable to ask that the increased cost of the more expensive devices be justified by demonstrating benefit additional to that obtained with less expensive devices" (p. 67).

Furthermore, Ventry and Weinstein (1982) pointed out that adequate rehabilitative management of an individual with hearing impairment depends in part on the assessment of the effects of the hearing impairment on the everyday function of that individual. These effects have remained largely inestimable using objective, in-clinic assessments, mostly because everyday function occurs in the natural environments of the individual and, therefore, cannot easily be captured by an objective measure in a clinical environment. For this reason, a multitude of outcome measures, typically questionnaires, have been developed over the past few decades that focus on the subjective assessment of hearing, hearing problems, and outcomes of hearing aid fitting (see Bentler & Kramer, 2000; Noble, 1998, for extensive reviews). When assessing the outcomes of hearing aid fitting, subjective assessments provide data regarding individuals' perceptions of their communicative abilities, of many aspects of their aided listening (sound quality, comfort, convenience of use), and of satisfaction and changes in quality of life subsequent to hearing aid fitting.

As with any systematic data collection, subjective outcome assessments offer useful information both for the specific patient as well as for system management. The practitioner or organization seeking to complete outcome assessment needs to contemplate several factors, including the degree to which a specific tool meets psychometric standards, such as reliability and validity (Hyde, 2000) and the relative ease of use in a day-to-day clinical setting. Beck (2000) described the characteristics of outcome assessments that are easy to use as follows: low respondent burden, easy to administer, not take too much time, and data management capability so that results can be scored and retained.

In addition to psychometric and practical concerns, practitioners or organizations may have specific areas of interest in sampling among the various domains of outcome, in the comprehensiveness of inquiry in a given domain, or even in how or when those domains are sampled. For example, the Hearing Aid Performance Inventory described by Walden, Demorest, and Hepler (1984) or its shortened version (Schum, 1992) would likely appeal to practitioners who prefer a single-administration assessment of benefit. Practitioners who value listener-specified situations and problems will use either the Client Oriented Scale of Improvement (COSI; Dillon, James, & Ginis, 1997) or the Glasgow Hearing Aid Benefit Profile (GHABP; Gatehouse, 1999). Practitioners more interested in assessing social and emotional adjustment might prefer the Hearing Handicap Inventory for Adults (Newman, Weinstein, Jacobsen, & Hug, 1991) or its predecessor, the Hearing Handicap Inventory for the Elderly (Ventry & Weinstein, 1982) as both emphasize emotional consequences and social and situational effects. Practitioners interested in estimating benefit by assessing an individual's perceptions of their speech communication abilities in quiet, in reverberation, and in background noise, as well as their perception of the aversiveness of sounds associated with hearing use will be attracted to the Abbreviated Profile of Hearing Aid Benefit (Cox & Alexander, 1995). Many more outcome measures exist that vary primarily in domain(s) assessed, complexity, and number of items. Up to 1999, however, only three outcome measures—Hearing Aid Review (Brooks, 1990), the Hearing Aid Users Questionnaire (Dillon et al., 1999), and the GHAPB—could truly be considered omnibus, in that they included assessments of the multiple

domains of benefit, use, and satisfaction. Recognizing the need for a measure that was brief, that could be used internationally, and that targeted multiple outcome domains, Cox et al. (2000) devised the seven-item International Outcome Inventory for Hearing Aids (IOI-HA) that included a question each on: use, benefit, residual activity limitations, satisfaction, residual participation restrictions, impact on others, and quality of life.

In 2001, the hearing care company Hearx/HearUSA participated in the American English normative study for the IOI-HA (Cox et al., 2003) and simultaneously began a process to select a standardized outcome measure for companywide adoption. In 2002-2003, the company completed an internal pilot study of 20 different outcome measure instruments (Nemes, 2003). Salient selection criteria were (a) ease of administration, (b) coverage encompassing a variety of critical outcome domains and needs prior to and following hearing aid fitting, and (c) the capacity for standardized data collection and entry, thus permitting data aggregation and analysis across a network encompassing approximately 175 offices at that time. Because none of the existing outcome measures met all the above criteria, and because of an intent to incorporate as much as possible of the IOI-HA, a decision was made to blend the questions of the IOI-HA into one of those existing measures, the Self-Assessment of Communication (SAC; Schow & Nerbonne, 1982), thus yielding a revised and updated version of SAC, operationally named SAC-Hx. Based on the pilot study, the SAC-Hx was selected for companywide implementation and has been in use to the present day. Additional information on the revised SAC is available at the SAC Web site (SAC, 2009).

In 2004, selected clinical sites in the Department of Veterans Affairs Healthcare System (hereafter, VA) awarded contracts to provide assessment and audiological rehabilitative services for eligible veterans who could not be scheduled within 30 days of their request for an initial audiology appointment. The requirements of the VA contract included the implementation of current standard of care practices and standardized collection and reporting of the assessment, fitting, and outcome data. A key factor in the required reporting was that outcome measures were necessary to validate the effects of treatment. Hearx/HearUSA was awarded a contract and subsequently participated in the hearing care of several thousand individuals in corporate-owned clinics, as well as independent audiology offices that were part of the HearUSA network. Because SAC-Hx had been adopted for companywide use, it was used as the outcome measure in this venture. To facilitate the collection of the data required by the VA, a proprietary, Web-based program was developed to capture the information and make it available to both the VA and the contractor for archival and quality management purposes.

As the data were collected and quality management reviews were conducted, the procedures and reporting methods allowed for analysis of the outcomes from more than 4,500 individuals fitted with hearing aids as a part of their treatment plan, all following standardized protocols. According to Cox (2005), one of the limitations of research in amplification is small participant groups leading to underpowered studies, therefore, the opportunity to share outcomes of hearing aid intervention using a formal subjective tool (here, SAC-Hx) in a very large group is compelling. In the present retrospective report, it was neither planned nor possible to separate the effects of the hearing aids from the counseling, psychosocial changes and other elements of the treatment, although recent research has examined non–hearing aid contributions to the audiological rehabilitation process in adults (Abrams, Chisolm, & McArdle, 2002; Chisolm, Abrams, & McArdle, 2004).

The purpose of this report is to present formal, subjective outcome findings in the largest group known to be reported. Simply stated, this report is a straightforward account of the routine application of a formal, subjective outcome assessment used as part of a standardized protocol in a sample of more than 4,500 individuals who were in the process of receiving hearing aid treatment for hearing impairment. In several respects, this report is similar to the report by Dillon et al. (1999): Both are truly large scale (Dillon et al., 1999, $N = 1{,}770$; present report, $N = 4{,}584$); both can be considered to be normative for the measures each used (COSI or SAC-Hx); both were "obtained under ordinary clinical conditions by many clinicians on clients who were not selected in any special manner" (Dillon et al., 1999, p. 68); and the majority of participants in each report were first-time hearing aid users whose degree of hearing impairment in the better ear could best be characterized as moderate or better. These two reports differ in one key respect: the outcome measure employed (COSI, Dillon et al., 1999, vs. SAC-Hx, present report).

One purpose of the present report is to quantify the obvious, consistent with the previous reports of Kochkin and Rogin (2000) and Chisolm et al. (2004), that hearing aid amplification is associated with improvement in a variety of domains. Additionally, this report describes outcomes for groups for several nominal categories of hearing impairment and describes outcomes for individuals with prior experience with hearing aid amplification as well as new users of hearing aid amplification. The following questions were addressed:

1. Does the provision of hearing aids as part of a standard of care that includes verification with probe microphones and scheduled follow-up visits improve the perception of communication abilities across relevant outcome domains?

2. Does prior experience with hearing aids affect outcomes when compared with those with no prior experience?
3. What is the relationship between degree of hearing impairment and self-perception of communication as assessed by the SAC-Hx?

Method

Participants

A total of 4,584 veterans with adult-onset hearing loss who were eligible to receive hearing aids through outpatient services from four VA Medical Centers in Florida and Texas were referred to the HearUSA Network for audiological assessment and hearing aid fitting from February 2004 to October 2005. VA physicians provided medical clearances for hearing aid fitting. All services and hearing aids were provided to the participants at no cost or, at most, a $50.00 copayment per visit. Because of the retrospective nature of the study, specific enumeration of participant age and gender is not available, although informal reports suggest that this sample consisted primarily of older males consistent with the current VA population.

Hearing Care/Hearing Aid Providers

As noted above, the HearUSA Network contracted with select VA medical centers to provide hearing aids and services for eligible veterans. This network includes independent audiologists as well as audiologists employed in Hearx and HearUSA company-owned centers. The collaborative arrangement between individual VA medical centers and a private contractor was initiated to reduce the waiting times for hearing aid–eligible veterans. Approximately 100 Hear USA audiologists in 48 locations in Texas and Florida followed protocols stipulated by the VA contract for audiological assessments, hearing aid fitting, and follow-up services, including a treatment outcome measure, which, consistent with companywide protocol, was SAC-Hx.

Procedures

Patients were selected and referred to the contractor according to VA criteria. All audiological and hearing aid services were delivered at contractor office locations. All procedures followed the contractor's set of uniform practice guidelines that included real-ear measurement using probe microphones for performance verification in all cases. Services were generally provided across a minimum of four office visits: first (audiological assessment, initial counseling, selection of hearing aids, ear impressions, and baseline SAC-Hx administration); second (hearing aid fitting, verification, and orientation that included appropriate educational counseling relative to the use, care, and maintenance of the hearing aid, battery safety, battery order procedures, and repair warranty information); third (follow-up appointment at 2-weeks postfitting); and fourth (follow-up appointment at 4 weeks postfitting with posttreatment SAC-Hx administration). Other appointments in this time frame were completed as necessary. At the follow-up appointments, audiologists verified hearing aid performance and addressed several topics: use, care, maintenance, insertion, listening strategies, expectations, battery issues, telephone use, comfort of aided listening, tolerance of aided loud sounds, and any other issues relevant to a particular case.

Standard assessment procedures included several items of history information; pure tone air conduction thresholds for 250, 500, 1,000, 2,000, 3,000, 4,000, 6,000, and 8,000 Hz; pure tone bone conduction thresholds for 500, 1,000, 2,000, 3,000, and 4,000 Hz; speech reception thresholds (SRT); word recognition scores for monosyllables (WRS); immittance testing as necessary; and most comfortable loudness level (MCL) and uncomfortable loudness level (UCL). The Hearx/HearUSA protocol for MCL uses running speech with an initial presentation level at 20 dB (SL) re: SRT, with running speech presented in 5 dB ascents until the listener affirms that the audiologist's voice is clear and comfortable. UCL is estimated using either pure tones or narrow bands of noise at 500 and 3,000 Hz and other frequencies as deemed appropriate by the audiologist, presented initially at 30 dB (SL) re: pure tone threshold and then in 5 dB ascents until the listener reports that the sound is uncomfortably loud. Recommendations for hearing aids followed VA criteria and audiologist's clinical judgment. All styles and sizes of hearing aids and all levels of technology available in 2004-2005 were used. Approximately 75 different models were fit, including most size variants within a given model line (e.g., Siemens model Prisma was fit in full shell, half shell, completely in canal, and behind the ear products). Three manufacturers supplied these hearing aids: Oticon (model Atlas); Phonak (models Aero, Claro, Perseo, Savia, Solo, Supero, and Valeo); and Siemens (models Acuris, Infiniti, Music, Phoenix, Prisma, and Triano). Verification of hearing aid fitting employed real-ear measures using probe microphones to assess the accuracy of performance, usually to a National Acoustic Laboratories–Revised target (Byrne & Dillon, 1986). Amplification parameters were modified as needed, based on participant preferences or audiologist's clinical judgment. In all cases, individual practitioners were satisfied that hearing aid fittings met appropriate performance standards.

Throughout service delivery, the contract audiologists entered 93 items of patient information into a secure Web-based software system designed for this project, the Veterans Affairs Referral System (VARS). To safeguard

confidentiality, participants were entered into VARS using a VA-provided identification code number. Data entries included audiological test results, pre- and posttreatment SAC-Hx item responses, hearing aid information, and several case history items as follows. Participants were asked if they were currently using amplification, and if so, was that amplification satisfactory or unsatisfactory. Additionally, if a participant was currently using amplification, the participant was asked whether the duration of use was either 1 to 4 years or 5 or more years. Responses for these amplification questions were tallied separately for right ear and for left ear. Participants were also asked to select the duration of their hearing loss from the following menu: none, within the past 90 days, less than 1 year, 1 to 4 years, or 5 years or more. Finally, participants were asked if there was a history of hearing loss in their family, if they had a history of noise exposure, and if they had a complaint of dizziness or spinning.

Treatment Outcome Measure: SAC-Hx

According to Schow and Nerbonne (1982), the design intent of SAC was to create a screening tool that incorporated elements from more comprehensive subjective measures that existed at that time. To this end, 6 of the 10 original SAC questions (Items 1-6) derived primarily from the 158-item Hearing Performance Inventory (HPI; Giolas, Owens, Lamb, & Schubert, 1979) and the remaining four items (Items 7-10) derived from the Denver Scale of Communication Function (DSCF; Alpiner et al., unpublished study cited in Schow & Nerbonne, 1980). In SAC, Schow and Nerbonne (1982) employed scoring methodologies originally described by High, Fairbanks, and Glorig (1964) for use with the Hearing Handicap Scale (HHS). As in HHS, both SAC and SAC-Hx used a 5-item Likert-type response format along a continuum of relative frequency of occurrence. For SAC and SAC-Hx, participants responded using the numbers "1" through "5" in which 1 = *almost never (or never)*, 2 = *occasionally (about 1/4 of the time)*, 3 = *about 1/2 of the time*, 4 = *frequently (about 3/4 of the time)*, and 5 = *practically always (or always)*. As in HHS, both SAC and SAC-Hx included a procedure to convert raw scores into a total scaled score with a range of 0 to 100. For SAC and SAC-Hx, the language and response choices were written so that lower values indicate less severe self-perceived problems and higher values indicate greater degrees of self-perceived problems. For example, if a participant responded to questions such as "Do you experience communication difficulties in . . ." with all "1" responses ("*almost never or never*"), these raw scores converted into a total scaled score of 0. Conversely, if a participant responded to these same questions with all "5" responses ("*practically always or always*"), these raw scores converted into a total scaled score of 100.

The SAC-Hx revision expanded the original SAC to 12 items, including 8 of the 10 questions found on the original SAC, although these 8 were renumbered, reordered, and modified to incorporate the content of 6 of the 7 items of the IOI-HA, excluding only IOI-HA Item 5 ("Over the past 2 weeks, with your present hearing aid(s), how much have your hearing difficulties affected the things you can do?"). SAC-Hx items are displayed alongside the original SAC items in Appendix A. Compared with SAC, one new question (5) on SAC-Hx provides for the participant to specify a situation in which communication difficulty is experienced. This question style is borrowed from the specific goal attainment scaling methodology that is foundational to COSI and GHABP. SAC-Hx includes six questions assessing activity limitations for communication (1, 2, 3, 4, 5, and 6), and one question each on participation restrictions (7), perception of individual's own emotions (8), perception of the attitudes of others (9), quality of life (10), hours of use of hearing aids (11), and overall satisfaction with hearing aids (12). The questions on SAC-Hx appear on or are thematically consistent with questions found on at least 18 other commonly, and some not so commonly, used measures (see Appendix B). In summary, SAC-Hx represents an IOI-HA/COSI/GHAPB-influenced revision of the SAC (itself originally influenced by HHS and derived from HPI and DSCF). (See Appendix C for the SAC-Hx questionnaire form used in this project.)

In the present project, SAC-Hx was administered twice: first, at the initial assessment; and second, within 4 to 6 weeks postfitting. Questions 1 to 10 from the SAC-Hx were either posed in a face-to-face format in which the audiologist read aloud each question to the participant, or the participants were instructed and completed the SAC-Hx in a paper-and-pencil format. Individual item responses were input into VARS, which then automatically calculated a scaled score that ranged from 0 to 100. Because the VARS software was designed to capture pre- and postdata, the postfitting responses to the remaining two questions regarding hearing aid use and satisfaction were not entered into the system although these responses were collected at most office locations. Therefore, information regarding hearing aid use and satisfaction is not possible in this report.

Derivation of Communication Consequence Category Boundaries and Labels

Sturmak (1987) related SAC scores to pure tone sensitivity in a sample of 806 adults with varying degrees of hearing sensitivity and identified SAC scores for the boundaries for four categories of progressively poorer outcomes, termed *handicap ranges*, and given the labels "normal," "slight," "mild-moderate," and "severe." (These values are depicted in Table 1 for both raw and scaled scores). These values were incorporated into the American Speech-Language Hearing

Table 1. Values for Category Ranges for SAC (Sturmak, 1987) and SAC-Hx (present report)

Category Labels for SAC	Scaled Scores for SAC	Scaled Scores for SAC-Hx	Category Labels for SAC-Hx
Normal	0-20	0-20	Normal
Slight	21-40	21-40	Mild
Mild to moderate	41-70	41-60	Moderate
		61-80	Severe
Severe	71-100	81-100	Profound

Note: SAC = Self-Assessment of Communication; SAC-Hx = revised version of the Self-Assessment of Communication.

Association (1997) policy document, "Guidelines for Audiologic Screening," specifically in the subsection titled, "Screening for Hearing Disability—Adults." In the nomenclature common at that time, "handicap" denoted the disadvantages that prevented or limited the fulfillment of a role that is normal, and "disability" denoted the restriction or lack of ability to perform activities in a manner or range considered to be normal (Brooks, 1989; Noble, 1998; Stephens & Hétu, 1991). In this context, and on review of the original items, SAC appears to be more of a "disability" measure than a "handicap" measure. In the currently recommended nomenclature found in World Health Organization (2002) International Classification of Functioning, Disability and Health recommendations, the concepts earlier embodied in "handicap" now are termed *participation restrictions* and the concepts formerly known as "disability" are now termed *activity limitations*. In contemporary terms, Hickson, Worrall, and Scarinci (2007) characterized SAC as a measure of communication activity limitation. Although also loaded with communication activity limitation questions, SAC-Hx is by its nature an inventory of multiple domains, and as such, assesses both participation restriction and activity limitation. In this report, the collective concepts of participation restriction and activity limitation due to hearing impairment will be termed simply *consequences* (Helvik et al., 2006).

To facilitate the analysis of this large database, a finer definition of communication consequence categories was adopted that paralleled the original SAC categories as much as possible. In the modifications employed in the present report, a fifth communication consequence was added and the labels for the five categories were changed to align with the labels also used to describe hearing impairment ("normal," "mild," "moderate," "severe," "profound"). The labels and scaled score boundaries created for the SAC-Hx are displayed in Table 1, alongside the labels and scaled score boundaries for the original SAC.

The primary domain under analysis in this report is benefit, what Humes (1999) described as the degree of change from unaided to aided listening. As Dillon et al. (1999) pointed out, benefit is multidimensional and may include a reduction in activity limitations for communication, a reduction in participation restrictions, and a reduction in negative emotions. In this report, benefit is operationally defined as the difference between the baseline SAC-Hx scores (hereafter, "Pre-SAC") as compared with the posttreatment SAC-Hx scores (hereafter, "Post-SAC"). A comparison of Pre-SAC with Post-SAC would appear to provide evidence to support a reduction in activity limitations for communication (Items 1, 2, 3, 4, 5, and 6), a reduction in participation restrictions (Item 7), a reduction in negative emotions both by self and others (Items 8, 9, and 10), and an improvement in quality of life (Items 7 and 10). The application of the original SAC as a measure of hearing aid benefit (comparing pre–hearing aid SAC total score to post–hearing aid SAC score) was originally described by Gailey (1987) who found a statistically significant improvement of 30 points in a sample of 71 adults fit with hearing aids in audiology private practice locations. In his study, Gailey (1987) did not find any statistically significant relationships between benefit and age, gender, time between SAC administrations, or mode of administration of test.

Degree of Hearing Impairment Categories

Generally, increased severity of self-perceived communication problems aligns with poorer hearing sensitivity, a relationship initially documented by the U.S. Public Health Service National Health Survey (NHS) conducted in 1935 and 1936. In the 1935-1936 NHS, more than 9,000 individuals had their pure tone hearing thresholds measured and as well, they self-categorized their hearing difficulties by selecting among four categories along a continuum of difficulty in hearing and understanding speech (Beasley, 1940). That survey provided the first formal alignment of hearing impairment using modern audiometers and self-assessment of communication difficulties. This relationship was also examined in the present report. Consistent with the current VA disability ratings regulations, the pure tone average of the audiometric thresholds at 1,000, 2,000, 3,000, and 4,000 Hz was employed as the exemplar of hearing impairment (Schedule for Rating Disabilities, 1999). For categorization and analysis, five commonly used labels for severity of hearing impairment were used with the following dB hearing level (HL) category boundaries: within normal limits ≤25 dB HL; mild hearing impairment = 26 to 44 dB HL; moderate hearing impairment =

Table 2. Mean Air Conduction Audiometric Results (in dB HL) for 4,584 Participants

		250 Hz	500 Hz	1,000 Hz	2,000 Hz	3,000 Hz	4,000 Hz	6,000 Hz	8,000 Hz
Right ear	Mean	33.49	33.99	38.70	53.10	65.31	71.89	75.03	75.03
	SD	17.03	17.55	17.85	18.11	16.76	17.02	17.86	17.53
	Range	0-115	0-120	0-115	0-120	0-120	10-120	5-120	5-120
	n	4,561	4,573	4,567	4,555	4,469	4,475	4,017	3,994
Left ear	Mean	33.29	33.88	38.78	54.60	66.53	72.84	75.67	75.23
	SD	16.82	17.38	17.98	17.64	16.02	16.25	16.82	16.45
	Range	0-115	0-115	0-120	5-115	0-120	10-120	10-120	5-110
	n	4,549	4,557	4,561	4,546	4,466	4,471	3,980	3,966

45 to 64 dB HL; severe hearing impairment = 65 to 84 dB HL; and profound hearing impairment ≥85 dB HL. These specific category boundaries were derived from Olsen's (1998) transformation of the mean hearing thresholds for each hearing difficulty category as reported by Beasley (1940). These values approximate the values typically used by audiologists to categorize hearing impairment in adults (Clark, 1999; Goodman, 1965; Kaplan, Gladstone, & Lloyd, 1993; Margolis & Saly, 2007; Roeser & Clark, 2007).

Statistical Analyses

Because specific participant identifiers were not entered into VARS, retrospective analysis of clinical data could be accomplished without compromising participant privacy. The data obtained from the participants at the initial assessment and at the postfitting appointment approximately 4 weeks later were examined using *t* tests and general linear model repeated measures analyses of variance (ANOVA). Significant main effects and interactions were examined further by one-way ANOVAs or Tukey post hoc tests. The significance level for each of the ANOVAs and post hoc analyses was set to $p < .001$. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) Version 14.0.

Results

Participants

The database consists of 4,584 participants. Descriptive air conduction threshold results in Table 2 reveal mean audiometric findings consistent with a mild to severe, sloping hearing impairment, as would be expected in an adult-onset population. Although not included in this table, the majority of participants had sensorineural hearing impairment (90.3% having this type of impairment in both ears). Additionally, the majority of participants (78.2%) had bilateral hearing impairment that could be characterized as symmetrical, when defined as a 10 dB HL or less difference in the pure tone average (PTA) of the audiometric thresholds at 500, 1,000, and 2,000 Hz compared across ears. An additional 12.8% had borderline asymmetry (10.01-20 dB HL PTA difference) and 9% could be considered asymmetrical (PTA difference across ears in excess of 20 dB HL).

Table 3. Selected Characteristics of 4,584 Participants

Characteristic	Subset	*n* (%)
Total sample		4,584 (100%)
Prior amplification experience	Neither ear	3,281 (71.6%)
	Both unsatisfactory	767 (16.7%)
	Mixed outcome	274 (6.0%)
	Both satisfactory	82 (1.8%)
	Missing data	180 (3.9%)
Prior amplification duration	1-4 years (either ear)	351 (7.7%)
	5+ years (either ear)	877 (19.1%)
	No response/NA	3,356 (73.2%)
Family history of hearing loss	Yes	1,252 (27.3%)
	No	3,332 (72.7%)
History of noise exposure	Yes	3,727 (81.3%)
	No	857 (18.7%)
History of dizziness	Yes	596 (13.0%)
	No	3,988 (87.0%)

Table 3 provides information about prior amplification experience, duration of prior amplification experience, family history of hearing impairment, history of noise exposure, and history of dizziness. The majority of participants had a negative family history for hearing impairment (73%) and a negative history for dizziness (87%). The majority of these participants (81%) indicated a positive history of noise exposure, not surprising in an adult-onset, veteran population.

In this sample, 3,281 participants (71.6%) had no prior amplification experience in either ear. For the 1,123 participants who reported prior amplification experience, 1,041 (92.6% of this subgroup) reported that their experience was unsatisfactory in both ears or in one ear (indicated as "mixed outcome"), leaving only 82 participants (7% of this subgroup) who indicated satisfactory amplification experience for both ears. Although the actual reasons for this magnitude

Table 4. Descriptive Data for SAC-Hx Items 1 to 10 for 4,584 Participants

	Pre-SAC-Hx			Post-SAC-Hx			*t* Test	
SAC-Hx item	Mean	*SD*	Item–Total *r*	Mean	*SD*	Item–Total *r*	Mean Difference	*p*
1. One-to-one	3.42	1.13	.71	1.92	1.10	.82	1.49	<.001
2. TV, etc.	3.75	1.12	.72	2.02	1.11	.80	1.73	<.001
3. Small group	3.82	1.08	.75	2.17	1.05	.79	1.64	<.001
4. Unfavorable	4.38	0.92	.65	2.66	1.13	.66	1.71	<.001
5. What situation	3.97	1.02	.68	2.24	1.17	.74	1.72	<.001
6. Environmental	3.24	1.26	.63	1.85	1.11	.75	1.39	<.001
7. Social life	3.53	1.26	.79	1.86	1.11	.83	1.66	<.001
8. Worries, annoys	3.50	1.30	.72	1.96	1.17	.77	1.53	<.001
9. Others annoyed	3.64	1.24	.64	1.93	1.15	.77	1.71	<.001
10. Life enjoyment	3.38	1.25	.78	1.84	1.11	.84	1.53	<.001

Note: SAC-Hx = revised version of the Self-Assessment of Communication.

of dissatisfaction cannot be directly ascertained, an important consideration is that these participants requested audiology and hearing aid services, signaling the presence of a residual problem or problems in their communicative life that their present amplification had not completely resolved. Alternatively, it is appropriate to consider that there may be an element of response bias at play; perhaps these participants felt that an acknowledgment of satisfaction with their present amplification would introduce a barrier to the receipt of new products and services. As shown in Table 3, for those participants with prior amplification experience, 877 (71% of this subgroup) had worn amplification for 5 years or more and 351 (29% of this subgroup) had worn amplification for 1 to 4 years. As Kochkin (1997, 2000) demonstrated, overall satisfaction and benefit declines progressively and significantly as age of the amplification device increases, with the poorest levels of overall satisfaction noted for hearing aids 5 or more years of age. In this context, it is not surprising that the experience provided by the relatively old hearing aids in use by the majority of these participants was rated as unsatisfactory.

SAC-Hx

An item analysis was conducted on the Pre-SAC and Post-SAC assessments, separately, revealing strong internal reliability. For the Pre-SAC, the Cronbach α (an index of internal reliability) was .92, with interitem correlations averaging .54 and ranging from .40 to .75. For the Post-SAC, the Cronbach α was .95, with interitem correlations averaging .64 and ranging from .47 to .78. Descriptive data for the 10 SAC-Hx items are displayed in Table 4. Pearson *r* correlation data reveal high item–total correlations indicating, as with the Cronbach alpha findings, a highly internally reliable instrument. These analyses demonstrate that the 10 SAC-Hx items are strongly interrelated, with no individual item incongruent with any of the other items. Additionally, the mean difference (Pre-SAC vs. Post-SAC) was statistically significant ($p < .001$) for each of the 10 SAC-Hx items. The correlation between the Pre-SAC and Post-SAC measures was only .17, not surprising given the significant intervention with hearing aids between those two assessments. Test–retest reliability of the revised SAC was not assessed in this project but has been demonstrated to be excellent ($r = .94$) in samples of persons with normal and impaired hearing (SAC, 2009).

Benefit (Pre-SAC Compared With Post-SAC)

In this sample, mean Post-SAC scores were significantly improved compared with Pre-SAC scores. The mean Pre-SAC score on the baseline assessment was 66.46 (SD = 22.34), in the middle of the severe consequence category (61-80). After hearing aid fitting, the mean Post-SAC score was 26.15 (SD = 23.06), placing it at the low end of the mild consequence category (21-40). This difference, operationally defined as benefit, was highly significant, $t(4583) = 93.16$, $p < .001$, indicating a highly significant improvement. Approximately 61% of these participants had Pre-SAC scores in the severe and profound consequence categories and an additional 25% had scores in the moderate consequence category. Only 3% of this large sample had Pre-SAC scores in the normal consequence category. In contrast, following hearing aid fitting, 51% of this sample had Post-SAC scores in the normal category and an additional 29% had scores in the mild consequence category. Therefore, prior to hearing aid fitting, 86% of these participants perceived their hearing function and consequences to be in the moderate, severe, or profound consequence category; after hearing aid fitting, 80% of this sample perceived their function and consequences to be normal or mild. This dramatic reversal in self-perceived consequences in this sample is illustrated in Figure 1.

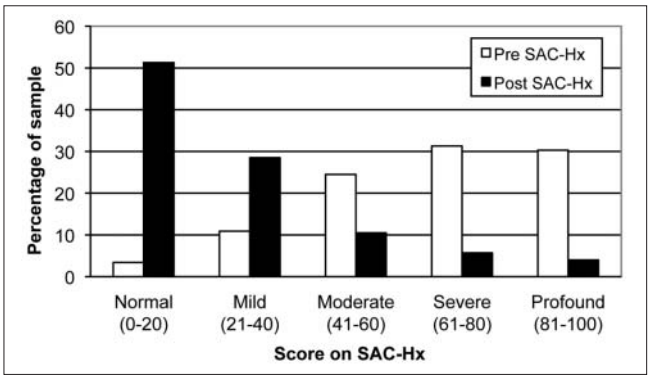

Figure 1. Pre– and post–hearing aid fitting SAC-Hx scores shown as a percentage of total participants according to five categories of outcome
Note: SAC-Hx = revised version of the Self-Assessment of Communication. See Table 1 for category boundary values.

Benefit (Pre-SAC Compared With Post-SAC) as a Function of Category of Self-Perceived Communication Consequence

Mean SAC scores changed dramatically and positively in each category of self-perceived communication consequence. Table 5 tracks the outcome for each of the five specific categories. In this sample, 3,864 participants (84.3%) demonstrated a reduction in hearing and communication problems (an improvement in function) after being fitted with hearing aids. For example, in considering the 1,375 participants who scored in the profound category on the Pre-SAC, a remarkable 1,295 (94.2%) improved on the Post-SAC with most of this improvement (992 participants, 76.6%) demonstrated by changes into either the normal or mild categories. A total of 2,230 participants (94.7%) scored in the mild (323), moderate (621), severe (715), or profound (571) categories on the Pre-SAC, but then scored in the normal category on their Post-SAC. Despite this overwhelming demonstration of benefit, it is correct to acknowledge that this dramatic change in perceived functional status did not occur for all persons fitted with hearing aids. Cumulatively, 720 participants (15.7%) stayed at the same or progressed to a more severe level after being fitted with hearing aids. Specifically, 487 persons (10.6%) did not change from their initial category after being fitted with hearing aids and an additional 233 persons (5%) indicated worse self-perceived functioning after being fitted with hearing aids. Based on their Post-SAC scores, the majority of these individuals acknowledged pervasive and serious communication problems that hearing aid amplification could not address nor resolve. Further analyses will be required to identify any definitive features of those who did not respond to intervention.

Further examination of Table 5 shows that there were 154 individuals who scored in the normal range on their Pre-SAC assessment (3.3% of the total group), despite meeting the criteria to receive hearing aids. These individuals seemingly had few if any self-perceived hearing or communication problems. Audiologists have known for years that having organic hearing impairment does not necessarily equate to having hearing problems. The majority of individuals with Pre-SAC scores in the normal category remained in the normal category on Post-SAC (123 participants, 79.9%); however, 31 other participants (20% of this group) with Pre-SAC scores in the normal category actually did poorer, and 8 of these participants fell two or more categories (from normal to moderate, and from normal to profound) following hearing aid fitting. Because this number is so small, these 8 participants likely reflect unusual idiosyncrasies. For example, in an examination of their actual scores, it was observed that 3 of these 8 had ceiling scores of 100 on their Post-SAC assessments, possibly signaling extreme dissatisfaction with their particular hearing aid, their audiologist, or some aspect of their hearing aid fitting experience.

Effect of Prior Experience With Amplification: Quality of Experience

The impact of prior experience and the perceived quality of that experience with amplification was investigated. Separate questions explored the participants' experience with left and right ears, but for purposes of analyses these questions were combined. As already noted, the majority of these participants had no prior experience with hearing aids (3,281 participants, 71.6%) and for those who had experience with amplification, the overwhelming majority, 1,041 (92.6%) indicated that their experience with amplification was unsatisfactory. Although duration of experience with amplification will be examined more closely in a following section, it is relevant to point out that 71% of all previous users of amplification had hearing aids aged 5 years or more and therefore, consistent with Kochkin (1997, 2000), it is not surprising that the majority of users of hearing aids in the present study indicated that their experience with amplification was unsatisfactory.

SAC-Hx scores significantly improved for each of the four quality of experience groups (see Figures 2 and 3). Although the inexperienced group tallied the largest scaled point improvement following hearing aid fitting (40.9 points), those who had prior unsatisfactory experience claimed essentially the same magnitude of benefit (40.4 points) following the fitting of new hearing aids and even those who initially indicated prior satisfaction with hearing aids significantly improved after the new fitting (average improvement of 28.9 points). These influences were explored using a 2×4 mixed ANOVA. As would be expected, Post-SAC scores were significantly

Table 5. Categorical Placement of Participants Based on a Comparison of Pre-SAC-Hx and Post-SAC-Hx Categories

		Pre-SAC-Hx Categories					
		Normal (0-20)	Mild (21-40)	Moderate (41-60)	Severe (61-80)	Profound (81-100)	*n*
Post-SAC-Hx categories	Normal (0-20)	123 (79.9%)	323 (64.9%)	621 (55.3%)	715 (49.9%)	571 (41.5%)	2,353
	Mild (21-40)	23 (14.9%)	110 (22.1%)	314 (28.0%	439 (30.6%)	421 (30.6%)	1,307
	Moderate (41-60)	4 (2.6%)	37 (7.4%)	103 (9.2%)	157 (10.9%)	180 (13.1%)	481
	Severe (61-80)	0 (0.0%)	14 (2.8%)	51 (4.5%)	71 (5.0%)	123 (8.9%)	259
	Profound (81-100)	4 (2.6%)	14 (2.8%)	34 (3.0%)	52 (3.6%)	80 (5.8%)	184
	n	154	498	1,123	1,434	1,375	4,584

Note: SAC-Hx = revised version of the Self-Assessment of Communication. Percentages are based on number of participants in the respective Pre-SAC-Hx categories.

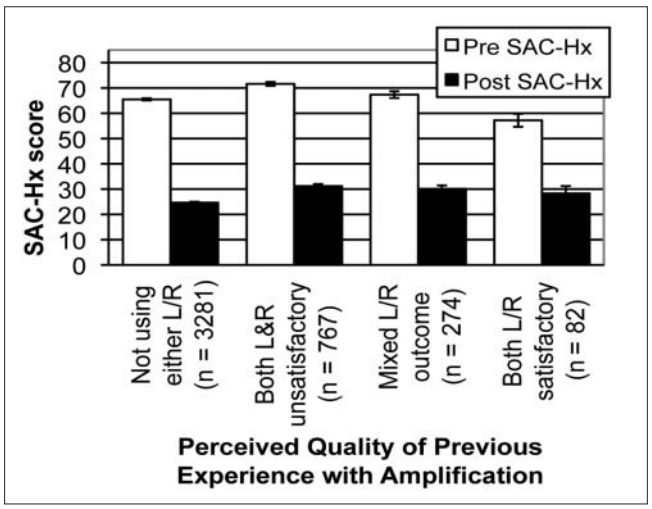

Figure 2. Pre– and Post–hearing aid fitting SAC-Hx scores shown based on quality of prior experience with amplification
Note: SAC-Hx = revised version of the Self-Assessment of Communication.

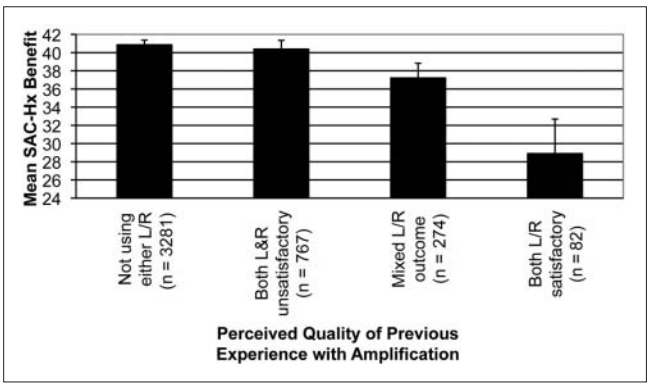

Figure 3. Benefit (difference between Pre-SAC-Hx and Post-SAC-Hx scores) shown based on quality of prior experience with amplification
Note: SAC-Hx = revised version of the Self-Assessment of Communication.

lower than Pre-SAC, $F(1, 4400) = 1464.45$, $p < .001$. There was also a significant main effect for prior experience, $F(3, 4400) = 31.20$, $p < .001$, and a significant interaction, $F(3, 4400) = 5.62$, $p = .001$. To further explore the interaction, two one-way ANOVAs were conducted separately on the Pre- and Post-SAC scores.

Prior amplification experience had a significant effect on Pre-SAC scores. Tukey post hoc tests revealed that participants who had satisfactory prior experience with hearing aids had significantly lower Pre-SAC scores than any of the other groups, meaning they had fewer self-perceived communication problems. This finding affirms one of the desired cardinal outcomes of hearing aid fitting; namely, that individuals fitted with hearing aids feel that those hearing aids provide a satisfactory experience and, simultaneously, ameliorate their communication problems. The problem, in this study and as reported by Kochkin (2000), is that the number of individuals who feel their amplification is satisfactory is woefully suboptimal; in the present report, the "satisfactory" subgroup constitutes only 7% (82/1123) of the prior experience with amplification group. Conversely, those with unsatisfactory or mixed outcomes had significantly worse Pre-SAC scores than either individuals with satisfactory prior experience or those with no prior experience. As noted above, given that the majority of experienced individuals had hearing aids that were 5 years or older, it seems likely that the previous fittings had deteriorated over those 5+ years for any of a number of common clinical conditions (e.g., progression of hearing loss, hearing aid failure, infrequent use, changes in users' lifestyles and communicative demands). It is also possible that those were poor fittings from the beginning. Alternatively, it is possible that some of these individuals felt they had to demonstrate on their Pre-SAC assessment that they were dissatisfied with their present hearing aids to qualify for new hearing aids. Regardless of the cause, prior experience status clearly had an effect on baseline SAC-Hx scores.

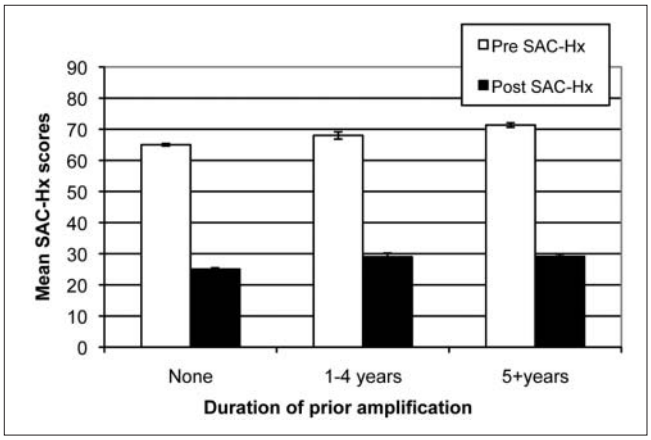

Figure 4. Pre– and Post–hearing aid fitting SAC-Hx scores shown based on duration of prior experience with amplification
Note: SAC-Hx = revised version of the Self-Assessment of Communication.

Similar analyses were conducted on the Post-SAC scores. The best scores after the new hearing aid fittings were obtained from participants who had no prior experience with hearing aids demonstrating significantly lower Post-SAC scores than those who had either unsatisfactory or mixed outcomes previously. Perhaps the improved functioning was more noticeable for these individuals. Possibly also, this could be attributed to a "honeymoon" or "halo" effect, given the relatively short time span between Pre-SAC and Post-SAC administrations. Finally, it may just be that these patients had not had adequate time to experience their hearing aids in diverse conditions. It would be interesting to see if these scores held up after more time.

As noted above, each of the four experience-with-amplification groups demonstrated significant statistical and functional benefit following fitting of new hearing aids. It is reassuring that the largest group (3,281 individuals with no prior experience) obtained a large magnitude of benefit following the fitting of hearing aids. It should serve as a note of optimism to professionals who fit hearing aids that the worst Pre-SAC score group (767 individuals with unsatisfactory prior experience) also achieved a large magnitude of benefit following the fitting of new hearing aids. Finally, even those who came in indicating prior satisfaction with hearing aids obtained significant benefit after new hearing aid fitting; thus, despite characterizing their amplification experience as satisfactory, for these individuals, new hearing aids provided improvement in their perceptions of their communication.

Effect of Prior Experience With Amplification: Duration of Experience

The duration of prior experience with amplification also had a significant effect on both Pre-SAC and Post-SAC scores (see Figure 4). Two separate questions (right ear, left ear) explored how long participants had previously worn hearing aids. Again, these separate questions regarding each ear were combined. Approximately 351 (7.7%) of all participants indicated having 1 to 4 years of experience with other hearing aids, 877 (19.1%) indicated having 5 or more years of experience, and 3,356 (73.2%) had no prior experience with hearing aids. A 2 × 3 ANOVA yielded significant main effects for benefit, $F(1, 4581) = 3993.29$, $p < .001$, and duration $F(2, 4581) = 34.46$, $p < .001$, but the interaction was not significant. The magnitude of benefit for each duration-of-experience group was large, significant, and comparable across groups (39-42 scaled points difference). Tukey post hoc tests revealed poorer Pre-SAC scores the longer the duration of prior experience with amplification. Post-SAC scores were best for those who had no prior experience with hearing aids; these scores did not differ between those with 1 to 4 years as compared with those with 5+ years of hearing aid experience.

Relationship Between Self-Perceived Ratings of Hearing/Communication Problems and Degree of Hearing Impairment

The degree of hearing impairment for each ear was derived based on pure tone air conduction threshold test results, specifically, a four-frequency PTA of hearing sensitivity at 1,000, 2,000, 3,000, and 4,000 Hz. The better (minimum) rating for either ear was identified and clients were categorized as follows: 118 (2.6%) were designated as normal (≤25 dB HL), 958 (20.9%) were rated as having mild hearing impairment (26-44 dB HL), 2552 (55.7%) as having moderate hearing impairment (45-64 dB HL), 890 (19.4%) as having severe hearing impairment (65-84 dB HL), and 65 (1.4%) as having profound hearing impairment (≥85 dB HL). These hearing impairment category ratings are shown in Table 6 as a function of Pre-SAC consequence category. Although the two category schemes use identical labels, it is probably best to consider the underlying numerical values and appreciate that these two continua were simply divided into categories, yielding a 5 × 5 matrix. Figure 5 portrays the relationship between the degree of hearing impairment (coded as the best performance for either ear) and Pre-SAC and Post-SAC means. A 2 × 5 ANOVA yielded a significant main effect for benefit, $F(1, 4578) = 1846.18$, $p < .001$; a significant main effect for severity of hearing impairment rating, $F(4, 4578) = 62.51$, $p < .001$; and a significant interaction, $F(4, 4578) = 19.86$, $p < .001$. A follow-up 1 × 5 independent groups ANOVA revealed a significant main effect on Pre-SAC means, $F(4, 4578) = 82.36$, $p < .001$. Tukey post hoc tests revealed that all pairs of means were significantly different, with the exception of the normal and mild impairment categories. As indicated in Figure 5,

Table 6. Categorical Placement of Participants Based on a Comparison of Pre-SAC-Hx Consequence Category and Degree of Hearing Impairment Category

		Pre-SAC-Hx Categories					
		Normal (0-20)	Mild (21-40)	Moderate (41-60)	Severe (61-80)	Profound (81-100)	*n*
Degree of hearing impairment based on pure tone average (500, 1,000, 2,000 Hz)	Normal (≤25 dB HL)	4 (2.6%)	20 (4.0%)	32 (2.8%)	42 (2.9%)	20 (1.5%)	118
	Mild (26-44 dB HL)	53 (34.4%)	164 (32.9%)	320 (28.5%)	259 (18.1%)	162 (11.8%)	958
	Moderate (45-64 dB HL)	81 (52.6%)	264 (53.0%)	630 (56.1%)	831 (57.9%)	746 (54.3%)	2,552
	Severe (65-84 dB HL)	16 (10.4%)	47 (9.4%)	135 (12.0%)	289 (20.2%)	403 (29.3%)	890
	Profound (≥85 dB HL)	0 (0.0%)	3 (0.6%)	6 (0.5%)	13 (0.9%)	43 (3.1%)	65
	n	154	498	1,123	1,434	1,374	4583

Note: SAC-Hx = revised version of the Self-Assessment of Communication. Percentages are based on number of participants in the respective Pre-SAC-Hx categories.

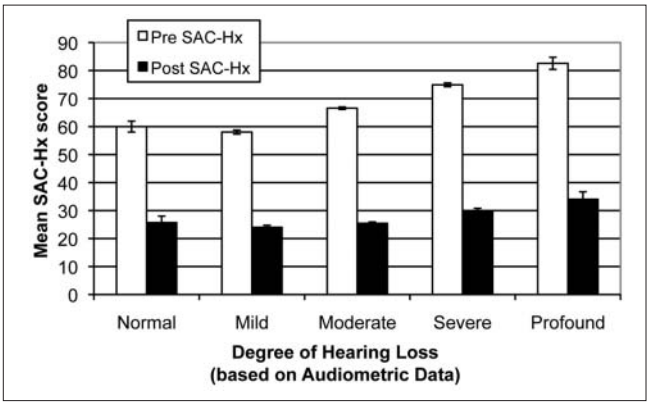

Figure 5. Pre– and Post–hearing aid fitting SAC-Hx scores shown based on degree of hearing impairment using a four-frequency pure tone average (1,000, 2,000, 3,000, and 4,000 Hz)
Note: SAC-Hx = revised version of the Self-Assessment of Communication. Normal ≤ 25 dB HL; mild = 26 to 44 dB HL; moderate = 45 to 64 dB HL; severe = 65 to 84 dB HL; and profound ≥ 85 dB HL.

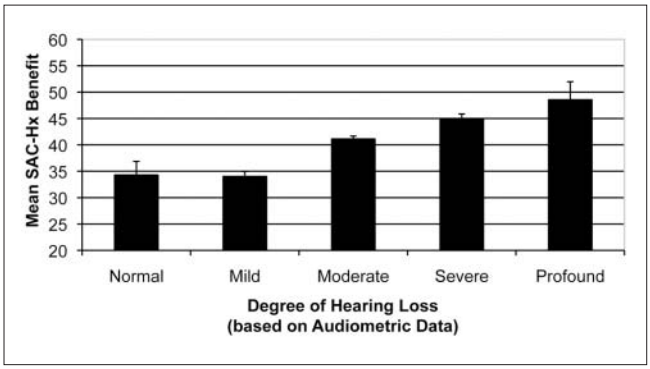

Figure 6. Benefit (difference between Pre-SAC-Hx and Post-SAC-Hx scores) shown based on degree of hearing impairment using a four-frequency pure tone average (1,000, 2,000, 3,000 and 4,000 Hz)
Note: SAC-Hx = revised version of the Self-Assessment of Communication. Normal ≤ 25 dB HL; mild = 26 to 44 dB HL; moderate = 45 to 64 dB HL; severe = 65 to 84 dB HL; and profound ≥ 85 dB HL.

Pre-SAC scores were nearly identical for those with normal or mild hearing loss, but then increased in a nearly linear fashion across moderate, severe, and profound categories. The correlation between the PTA categories and Pre-SAC categories was .24, with a slope of .36. Using the original continuous scores, the correlation was .28 with a slope of .46. Thus, on average, the severity of Pre-SAC ratings paralleled degree of hearing impairment based on mid–high-frequency audiometric results.

Figure 6 illustrates benefits (the difference between Pre-SAC-Hx and Post-SAC-Hx scores) as a function of degree of hearing impairment. Although constituting only 1.4% of this group, persons with profound hearing loss (operationally, those with a PTA of ≥85 dB HL) demonstrated the greatest magnitude of average benefit (48.5 scaled points of improvement) following hearing aid fitting. The combination of the 3,507 individuals with moderate, severe, and profound hearing loss demonstrated an average benefit in excess of 42 scaled points (41.1 points for the moderate impairment group, 44.9 points for the severe impairment group, and 48.5 points for the group with profound impairment) following hearing aid fitting. Even those classified as normal or with mild impairment manifested a gain of more than 34 points. From a delivery of care perspective, this clearly demonstrates that hearing aid amplification provided a statistical and functional improvement to all categories of hearing impairment.

Relationship Between Self-Perceived Ratings of Hearing/Communication Problems and Standard Audiologic Test Results

See Table 7 for Pearson correlations between Pre-SAC, Post-SAC, and several of the standard audiologic assessments: air

Table 7. Correlational Analyses Between Standard Audiometric Results and Pre-SAC-Hx Scores and Post-SAC-Hx Scores

	Post-SAC-Hx	Pre-SAC-Hx	Avg AC sens	Avg BC sens	SRT	WRS	WRS pres level	MCL
Pre-SAC-Hx	.168**							
Avg AC sens	.100**	.276**						
Avg BC sens	.078**	.220**	.732**					
SRT	.130**	.215**	.747**	.728**				
WRS	–.108**	–.221**	–.484*	–.383**	–.369**			
WRS pres level	.096**	.193**	.625**	.585**	.693**	–.326**		
MCL	.134**	.225**	.646**	.603**	.739**	–.307**	.929**	
UCL	.078**	.021	.248**	.251**	.379**	.002	.339**	.463**

Note: Avg AC sens = air conduction audiogram averaged across all test frequencies; Avg BC sens = bone conduction audiogram averaged across all test frequencies; SRT = speech recognition threshold; WRS = word recognition score for monosyllables; WRS pres level = presentation level for word recognition test; MCL = most comfortable loudness level; UCL = uncomfortable loudness level.
*$p < .05$. **$p < .01$.

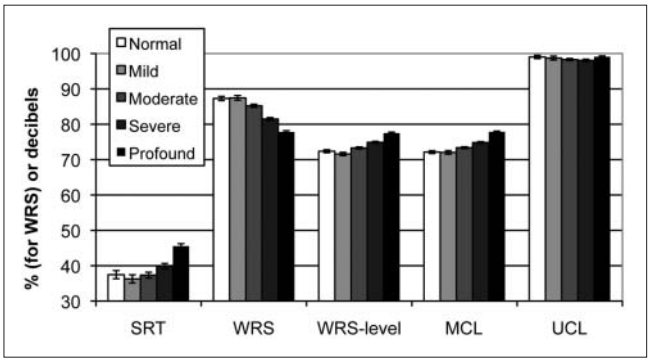

Figure 7. Audiological test results plotted across five consequence categories based on Pre-SAC-Hx scores
Note: SAC-Hx = revised version of the Self-Assessment of Communication.

conduction audiogram averaged across all test frequencies, bone conduction audiogram averaged across all test frequencies, SRT, WRS, presentation level for WRS, MCL, and UCL. As would be expected in a sample dominated by persons with a sloping, sensorineural hearing impairment, air and bone conduction test results not only highly intercorrelate but also are strongly related to SRTs. The marked relationship between the presentation level for WRS and MCL is not surprising given that WRS is commonly performed at MCL.

Although statistically significant, ostensibly due to the large *N* used in this analysis, there are no clinically meaningful correlations between standard audiologic test results and perception of communication consequences, either before or after hearing aid fitting. In contrast to the earlier analysis demonstrating significant differences in perception of communication consequences when impairment was defined by the mid–high-frequency PTA (1,000, 2,000, 3,000, and 4,000 Hz), this correlation analysis suggests that there is no meaningful relationship between the complete audiogram and perception of communication consequences for either Pre-SAC-Hx or Post-SAC-Hx. Specifically, all the correlations with the treatment outcome measure (Post-SAC-Hx) are less than .20, thus accounting for less than 4% of the variance in outcome. Scatterplots failed to reveal any nonlinear relationships, although some measures showed floor or ceiling effects. A multiple linear regression failed to suggest any sizable improvement in prediction compared with individual variables. It is interesting that the best predictor of outcome was the individual's initial rating of hearing problems as assessed by the Pre-SAC ($r = .168$).

Pre-SAC Scores and Speech Test Results

Some interesting patterns emerged between Pre-SAC scores and results from tests commonly employed in clinical audiology. Figure 7 portrays the relationship between the consequence category based on Pre-SAC score and the outcomes of tests such as SRT and WRS. SRT was significantly related to SAC consequence category, $F(4, 4547) = 61.55$, $p < .001$, but only those categorized in the profound consequence category required significantly greater intensity for SRT (45.5 dB HL). This finding is consistent with the earlier finding that individuals in a poorer SAC consequence category are likely to have a greater degree of hearing impairment and one that affects the base reception of conversational speech. There were no significant differences among the other consequence categories (37.5, 36.3, 37.3, and 39.9 dB HL for normal, mild, moderate, and severe categories, respectively). For these groups, their relatively better SRTs likely permitted adequate reception of conversational speech. For WRS, the main effect was again significant, $F(4, 3338) = 42.10$, $p < .001$. Tukey post hoc tests revealed that those classified in the severe and profound

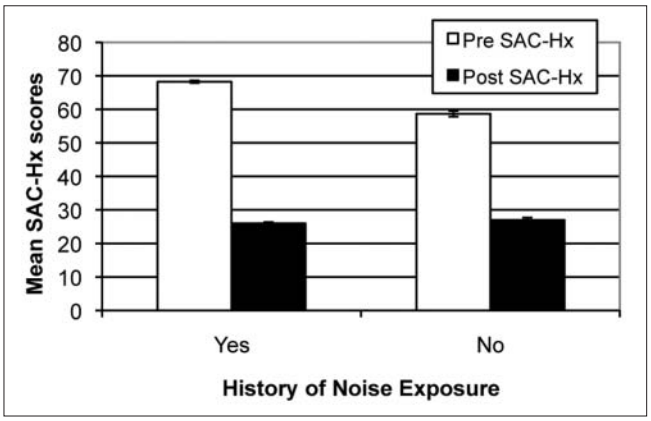

Figure 8. Pre– and Post–hearing aid fitting SAC-Hx scores shown based on history of noise exposure
Note: SAC-Hx = revised version of the Self-Assessment of Communication.

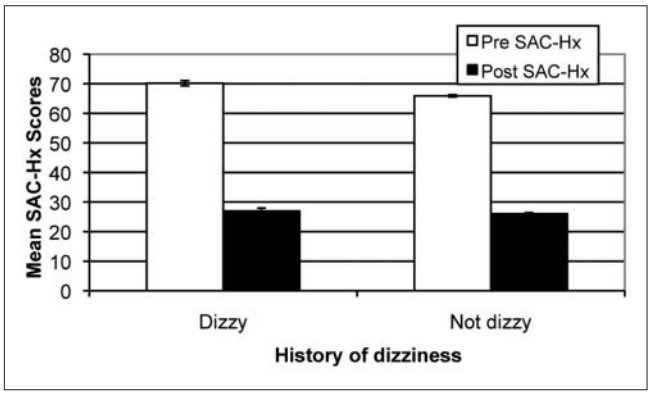

Figure 9. Pre– and Post–hearing aid fitting SAC-Hx scores shown based on history of dizziness
Note: SAC-Hx = revised version of the Self-Assessment of Communication.

consequence categories scored significantly poorer than any other category. On average, therefore, the two groups with the poorest Pre-SAC consequence scores also had the poorest monosyllabic word recognition scores. For MCL, there was again a significant main effect, $F(4, 3748) = 50.91$, $p < .001$. As with SRT, those classified in the profound consequence category had MCLs at significantly greater intensity than any other category. For UCL, there were no significant mean differences among the four consequence category groups with the mean range across groups from 98.08 to 99.08 dB (HL).

SAC Scores and Participant Demographics: History of Noise Exposure, History of Dizziness, and Family History of Hearing Loss

As previously discussed, 81.3% of the participants indicated they had a history of exposure to loud noise. A 2 × 2 ANOVA was conducted to explore the impact of a stated history of noise exposure on Pre- and Post-SAC scores. There was a significant main effect for benefit, $F(1, 4582) = 4535.28$, $p < .001$; a significant main effect for noise exposure, $F(1, 4582) = 42.66$, $p < .001$; and a significant interaction, $F(1, 4582) = 92.46$, $p < .001$. As illustrated in Figure 8, there was no difference in final Post-SAC scores, but those with a history of exposure to loud noise gave significantly poorer Pre-SAC ratings than those not so exposed.

Participants were also asked if they had a history of dizziness. A similar 2 × 2 ANOVA again revealed a significant main effect for benefit, $F(1, 4582) = 4174.89$, $p < .001$; a significant main effect for dizziness, $F(1, 4582) = 11.68$, $p = .001$; and a significant interaction, $F(1,4582) = 6.66$, $p = .01$. As illustrated in Figure 9, there was no difference in final Post-SAC scores, but those with a history of dizziness gave significantly poorer Pre-SAC ratings than those without such a history.

Approximately 27.3% of the participants reported a history of hearing loss in their family and 72.7% did not. There was no significant effect of family history on either Pre- or Post-SAC scores.

Discussion and Conclusions

As with only a very few studies, such as Dillon et al. (1999), this report examines the outcomes of a very large group following hearing aid treatment. The primary findings were robust, demonstrating the feasibility of further application of the SAC-Hx as a tool that easily addresses multiple domains. As in Dillon et al. (1999), the data were gathered as part of standard clinical practice by dozens of audiological practitioners following a standard protocol of hearing aid dispensing and dispensing hearing aids of uniform high quality.

Statistical analyses confirmed that hearing aid treatment when provided in a standard of care that followed standardized and generally accepted clinical procedures and included performance verification using probe microphone tests as well as counseling and education resulted in statistically significant benefit, defined as a change in the SAC-Hx score when assessed pre–hearing aid fitting and again post–hearing aid fitting. Benefit was robust and found in all four categories of poorer than normal communication consequence: Individuals with the poorest perceived communication consequences improved, as did individuals with relatively better perceived communication consequences. Overall, in this sample of 4,584 participants following hearing aid treatment, 84% felt that their communication consequences had improved, 15%

were unchanged, and 5% felt that their communication consequences were poorer.

Prior experience with amplification and the quality of that experience influenced benefit. Participants with no prior experience demonstrated the most benefit although, arguably, this effect may be confounded by their amplification naïveté. Regardless of the quality of prior experience with amplification (unsatisfactory, satisfactory, or mixed), all these groups demonstrated significant benefit following new hearing aid fitting. Participants who were dissatisfied with their prior hearing aids demonstrated benefit with new hearing aids, as did participants who had been satisfied with their prior hearing aids, although not to the same degree. Duration of prior experience with amplification did not have a remarkable effect on the magnitude of benefit as all three duration-of-amplification groups demonstrated robust, comparable, and significant benefit. However, when compared with inexperienced hearing aid users, participants with 5+ years of experience had both significantly poorer Pre-SAC scores and significantly poorer Post-SAC scores. For this group, it is possible that their poorer scores for each assessment represents simply the maturation of their perceptions—that is, a greater awareness of their communication problems, or alternatively, less reluctance to admit to these same problems, and an acknowledgement that amplification would not resolve all their communication problems.

When participants were categorized according to hearing impairment using a better-ear PTA at 1,000, 2,000, 3,000, and 4,000 Hz, all categories of hearing impairment demonstrated significant benefit following hearing aid fitting. Persons with profound hearing loss (operationally, those with a PTA of 85 dB HL or poorer) demonstrated the greatest magnitude of average benefit but persons with lesser degrees of impairment also demonstrated excellent and significant benefit. This underscores a key finding of this report, namely, hearing aid amplification provides a statistical and functional improvement to individuals in all categories of impairment served.

In this report, individuals who had histories of noise exposure and dizziness had significantly poorer Pre-SAC scores. It is not clear whether the awareness of these conditions heightened these individuals' self-perceptions of their communication difficulties, whether this is an artifact of ensuring access to care, or whether these comorbid conditions (especially dizziness) contribute to actual poorer communication consequences.

Degree of hearing impairment, when estimated by a better-ear PTA at 1,000, 2,000, 3,000, and 4,000 Hz, paralleled increasingly poorer communication consequences. On average, the more mid–high-frequency hearing impairment an individual had, the more likely they perceived communication consequences—increasing limitations in communication activities, participation restrictions and negative emotions, and decreasing quality of life. Additionally, average WRS was significantly poorer for participants in the two poorer communication consequence categories, providing evidence and a reminder that the organic inability to understand speech has a significant effect on individuals' perceptions of their communication difficulties.

This report has several limitations that may influence the generalizability of the main findings. A primary limitation concerns the participants, all of whom were veterans who received hearing aids at no cost (or low copayment per visit cost) through funding provided by the VA National Hearing Aid Program. Although the VARS software did not allow for the recording of age and gender, anecdotally, most of these participants were male, most of the participants were older, and likely, most could be characterized as "pre-Boomer." Therefore, for most of these participants, there may be cohort effects particular to this specific generation that includes selective survivorship and, primarily, its effects on health condition prioritization (Kochkin & Rogin, 2000; Wiley, Cruickshanks, Nondahl, & Tweed, 2000). Any possible age and gender interactions with the SAC-Hx are unknown at this time, except to say that two available reports using SAC that examined the interaction of age and gender with SAC did not show any significant age or gender effects (Gailey, 1987; Holcomb, Nerbonne, & Konkle, 2000).

Also, because of the intrinsic nature of a self-assessment measurement tool, participants could not be blinded and therefore, response bias effects, such as acquiescence (Walden et al., 1984), Hawthorne, "honeymoon," or "halo" effects were possible. Because actual hearing aid use (the treatment) was not recorded, it is possible that some hearing aids were not functioning properly, which could potentially weaken the effects reported here.

Additionally, although the SAC-Hx was constructed as a 12-item inventory assessing seven domains, 6 of the 12 items are devoted to one domain—namely, activity limitation for communication. In this report, data on use and satisfaction were not included; therefore, the data in this report encompass only five of the domains in the complete SAC-Hx. Furthermore, this report does not attempt to differentiate between outcomes in the different domains assessed by the SAC-Hx.

Finally, because the long-term stability of the benefit assessed by SAC-Hx is unknown at this time, predictions beyond the short-term benefits exemplified by the data in this report cannot be made with any certainty.

Appendix A

Comparison of Questions From SAC (1982) and SAC-Hx (ca. 2003)

	SAC	SAC-Hx	Comment
1	Do you experience communication difficulties in situations when speaking with one other person? (e.g., at home, at work, in a social situation, with a waitress, a store clerk, with a spouse, boss, etc.)	Do you experience communication difficulties in situations when speaking with one other person? (at home, at work, in a social situation, with a waitress, a store clerk, with a spouse, boss, etc.)	No change
2	Do you experience communication difficulties in situations when conversing with a small group of several persons? (e.g., with friends or family, co-workers, in meetings or casual conversations, over dinner or while playing cards, etc.)	Do you experience communication difficulties while watching TV and in various types of entertainment? (movies, radio, plays, night clubs, musical entertainment, etc.)	Revised Question 2 is slightly modified but thematically similar to Original Question 4
3	Do you experience communication difficulties while listening to someone speak to a large group? (e.g., in church or in a civic meeting, in a fraternal or women's club, at an educational lecture, etc.)	Do you experience communication difficulties in situations when conversing with a small group of several persons? (with friends or families, co-workers, in meetings or casual conversations, over dinner or while playing cards, etc.)	Revised Question 3 is Original Question 2
4	Do you experience communication difficulties while participating in various types of entertainment? (e.g., movies, TV, radio, plays, night clubs, musical entertainment, etc.)	Do you experience communication difficulties in situations when you are in an unfavorable listening environment? (at a noisy party, where there is background music, when riding in an auto or bus, when someone whispers or talks from across the room, etc.)	Revised Question 4 is Original Question 5
5	Do you experience communication difficulties in situations when you are in an unfavorable listening environment? (e.g., at a noisy party, where there is background music, when riding in an auto or bus, when someone whispers or talks from across the room, etc.)	How often do you experience communication difficulties in the situation where you want to hear better?	Revised Question 5 is a novel item to SAC-Hx
6	Do you experience communication difficulties when using or listening to various communication devices? (e.g., telephone, telephone ring, doorbell, public address system, warning signals, alarms, etc.)	Do you experience difficulty in hearing soft, medium, and loud environmental sounds appropriately (telephone ring, doorbell ring, traffic, horns, alarms)	Revised Question 6 is a modification of Original Question 6
7	Do you feel that any difficulty with your hearing limits or hampers your personal or social life?	Do you feel that any difficulty with your hearing limits or hampers your personal or social life?	No change
8	Does any problem or difficulty with your hearing upset you?	Does any problem or difficulty with your hearing worry, annoy, or upset you?	Revised Question 8 is expanded Original Question 8
9	Do others suggest that you have a hearing problem?	How often do others seem to be concerned or annoyed or suggest that you have a hearing problem?	Revised Question 9 is expanded Original Question 9
10	Do others leave you out of conversations or become annoyed because of your hearing?	How often does your hearing negatively affect your quality of life?	Revised Question 10 is a novel item to SAC-Hx
11		How many hours did you use your hearing aid on a daily basis?	Question 11 is a novel item to SAC-Hx
12		Please rate your overall satisfaction with your hearing aids.	This is a novel item to SAC-Hx

Note: Original SAC Questions 3 and 10 do not appear on SAC-Hx.

Appendix B

Correspondence of Questions on SAC-Hx (ca. 2003) to Other Existing Self-Reports

SAC-Hx	Origin/Other Scale	Item Nos.
1. Do you experience communication difficulties in situations when speaking with one other person? (at home, at work, in a social situation, with a waitress, a store clerk, with a spouse, boss, etc.)	APHAB	1, 4, 10, 12, 15, 23
	COSI	1
	CPHI	5, 10, 11, 17
	GHABP	Second "prespecified element"
	HAPI	2, 19, 22, 23, 24, 31, 32, 33, 34, 37, 40, 43, 44, 47, 52, 59, 61
	HAR	6a
	HHS	Form A: 2, 9, 11, 12, 14
	HMS	Section 1: 1
	HPI	1-7, 21, 22, 70, 74, 109, 110, 132-134
	SAC	1
	SHHI	1
2. Do you experience communication difficulties while watching TV and in various types of entertainment? (movies, radio, plays, night clubs, musical entertainment, etc.)	APHAB	5, 11, 18, 21
	COSI	5
	CPHI	9, 13
	GHABP	First "prespecified element"
	HAPI	1, 20, 21, 26, 30, 60
	HAR	6c, 6d
	HHIA	11, 15
	HHIE	15, 23
	HHS	Form A: 1, 3
	HMS	Section 1: 7, 8. 9, 10, 11
	HPI	14-19, 23, 24, 66
	SAC	4
	SHHI	10, 15
3. Do you experience communication difficulties in situations when conversing with a small group of several persons? (with friends or families, co-workers, in meetings or casual conversations, over dinner or while playing cards, etc.)	APHAB	6, 14, 16
	COSI	3, 15
	CPHI	3, 12, 14
	GHABP	Fourth "prespecified element"
	HAPI	29, 57, 58
	HAR	6b
	HHS	Form A: 15, 16
	HMS	Section 1: 3, 4
	HPI	10-13, 36-38, 112, 116, 118, 120-122, 135, 136
	SAC	2
	SHHI	2, 6, 7, 12
4. Do you experience communication difficulties in situations when you are in an unfavorable listening environment? (at a noisy party, where there is background music, when riding in an auto or bus, when someone whispers or talks from across the room, etc.)	APHAB	7, 9. 19, 24
	COSI	2, 4, 15
	CPHI	1, 2, 8, 15, 16
	GHABP	Third "prespecified element"
	HAPI	3, 5, 6, 7, 9-16, 18, 25, 27, 28, 35, 36, 38, 39, 41, 42, 45, 49-51, 53-55, 62-64
	HAR	6e
	HHIE	8
	HHS	Form A: 4-6, 10, 17, 18
	HMS	Section 1: 4
	HPI	8, 9, 20, 25-35, 39, 40, 42-56, 60, 61, 73, 75, 111, 113-115, 117, 119, 123, 137-144
	SAC	5
	SHHI	3, 9, 11, 13, 16, 18, 19, 20
5. How often do you experience communication difficulties in the situation where you want to hear better?	IOI-HA	2, 3
6. Do you experience difficulty in hearing soft, medium, and loud environmental sounds appropriately (telephone ring, doorbell ring, traffic, horns, alarms)	APHAB	3, 8, 13, 17, 20, 22
	COSI	8, 9, 10
	HHS	Form A: 19, 20
	HMS	Section 2: 12-19; Section 3: 22, 25
	HPI	57-59, 62-65, 69
	SAC	6 (with some modifications)

(continued)

Appendix B (continued)

SAC-Hx	Origin/Other Scale	Item Nos.
7. Do you feel that any difficulty with your hearing limits or hampers your personal or social life?	COSI	11, 12, 13, 14
	CPHI	84, 104, 109, 123, 145
	DSCF/QDS	5, 6, 11, 12
	HHIA	3, 16, 20, 23
	HHIE	3, 11, 13, 16, 18, 20, 23
	HMS	Section 7: 42
	HPI	124-127
	M-A Scale	20. 21, 23
	SAC	7
8. Does any problem or difficulty with your hearing worry, annoy or upset you?	COSI	13, 14
	CPHI	39, 57, 70, 74, 76, 82, 83, 91, 94, 96, 99, 103, 113, 143
	DSCF/QDS	9, 10, 17, 18, 21, 22
	HHIA	12, 17, 22
	HHIE	12, 17, 22
	HMS	Section 4: 28, 31, 33
	HPI	129, 130
	M-A Scale	6, 7
	SAC	8 (with slight expansion)
9. How often do others seem to be concerned or annoyed or suggest that you have a hearing problem?	CPHI	23, 49, 54, 59
	DSCF/QDS	1, 4
	HHIA	20
	HHIE	20
	HMS	Section 4: 29, 30
	IOI-HA	6
	M-A Scale	12
	SAC	9 (with expansion and slight modifications), 10
10. How often does your hearing negatively affect your quality of life?	CPHI	101, 106, 107, 112, 121, 122, 132, 136, 139, 142
	DSCF/QDS	10, 14
	HPI	128
	IOI-HA	7
	M-A Scale	4, 9, 2
11. If you are using a hearing aid: On an average day, how many hours did you use your hearing aids?	HAR	3
	HAUQ	2
	IOI-HA	1
12. Please rate your overall satisfaction with your hearing aids.	HAR	8
	HAUQ	5
	IOI-HA	4
	SADL	6

Legend

Abbreviation	Title	Reference
APHAB	Abbreviated Profile of Hearing Aid Benefit	Cox and Alexander (1995)
COSI	Client Oriented Scale of Improvement	Dillon, James, and Ginis (1997)
CPHI	Communication Profile for the Hearing Impaired	Demorest and Erdman (1987)
DSCF/QDS	Denver Scale of Communication Function/Quantified Denver Scale	Schow and Nerbonne (1980)
GHABP	Glasgow Hearing Aid Benefit Profile	Gatehouse (1999)
HAPI	Hearing Aid Performance Inventory	Walden, Demorest, and Hepler (1984)
HAR	Hearing Aid Review	Brooks (1990)
HAUQ	Hearing Aid Users Questionnaire	Dillon, Birtles, and Lovegrove (1999)
HHIA	Hearing Handicap Inventory for Adults	Newman, Weinstein, Jacobsen, and Hug (1991)
HHIE	Hearing Handicap Inventory for the Elderly	Ventry and Weinstein (1982)
HHS	Hearing Handicap Scale	High, Fairbanks, and Glorig (1964)
HMS	Hearing Measurement Scale	Noble (1978)
HPI	Hearing Performance Inventory	Giolas, Owens, Lamb, & Schubert (1979)
IOI-HA	International Outcome Inventory for Hearing Aids	Cox et al. (2000)
M-A Scale	McCarthy–Alpiner Scale of Hearing Handicap	McCarthy and Alpiner (1983)
SADL	Satisfaction with Amplification in Daily Life	Cox and Alexander (1999)
SAC	Self-Assessment of Communication	Schow and Nerbonne (1982)
SHHI	Social Hearing Handicap Index	Ewertsen and Birk-Nielsen (1973)

Appendix C

Sample of SAC-Hx Form

HEARx Your prescription for better hearing. **PATIENT SELF-ASSESSMENT OF COMMUNICATION (SAC)** HearUSA

Name: _____ **Date:** _____

Instructions: The purpose of this form is to identify the problems your hearing loss may be causing you. If you wear hearing aids, answer the questions according to how you communicate *when the hearing aids are in use*.

One of the five descriptions on the right should be assigned to each of the statements below.

Select a number from 1 to 5 next to each statement (please do not answer with yes or no and pick only one answer for each question.)

(1) Almost never (or never)
(2) Occasionally (about ¼ of the time)
(3) About ½ of the time
(4) Frequently (about ¾ of the time)
(5) Practically Always (or always)

(1) Do you experience communication difficulties in situations when speaking with one other person? (at home, at work, in a social situation, with a waitress, a store clerk, with a spouse, boss, etc.)	1 2 3 4 5
(2) Do you experience communication difficulties while watching TV and in various types of entertainment? (movies, radio, plays, night clubs, musical entertainment, etc.)	1 2 3 4 5
(3) Do you experience communication difficulties in situations when conversing with a small group of several persons? (with friends or families, co-workers, in meetings or casual conversations, over dinner or while playing cards, etc.)	1 2 3 4 5
(4) Do you experience communication difficulties when you are in an unfavorable listening environment? (at a noisy party, where there is background music, when riding in an auto or bus, when someone whispers or talks from across the room, etc.)	1 2 3 4 5
(5) How often do you experience communication difficulties in the situation where you most want to hear better? **Situation** _____	1 2 3 4 5
(6) Do you experience difficulty in hearing soft, medium, and loud environmental sounds appropriately (telephone ring, doorbell ring, traffic, horns, alarms).	1 2 3 4 5
(7) Do you feel that any difficulty with your hearing negatively affects or hampers your personal or social life?	1 2 3 4 5
(8) Does any problem or difficulty with your hearing worry, annoy or upset you?	1 2 3 4 5
(9) How often do others seem to be concerned or annoyed or suggest that you have a hearing problem?	1 2 3 4 5
(10) How often does your hearing negatively affect your enjoyment of life?	1 2 3 4 5

(11) If you are using a hearing aid: On an average day, how many hours did you use your hearing aids?

hours _____/16=_____%

Please rate your overall satisfaction with your hearing aids.

1☐ not at all satisfied (0%) 2 ☐ slightly satisfied (25%) 3 ☐ moderately satisfied (50%) 4 ☐ mostly satisfied (75%) 5 ☐ very satisfied (100%) _____%

FOR OFFICE USE ONLY
☐ Pre- Assessment ☐ Post- Assessment
☐ Not currently using Hearing Aids ☐ Current Hearing Aid User

Score : (Q1-10)_____(/10)_____-1 _____ x 25 = _____%

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